CONCLUSIONS

AND

RECOMMENDATIONS

OF

BUREAU EROS COORDINATORS

FOR

DEPARTMENTAL REVIEW

OF

EROS PROGRAM

NOVEMBER 4, 1977

Sent to Joan Davenport by Bailey
she gave it to Hank Smith
Hemp has copy

Response to Actio tem #7 listed in memorandum fr Gordon Law . . . dated June 19, 1977

Action Item 7, "Evaluate the present Departmental and management position of the EROS Program and possible administrative improvements to assure maximum effectiveness for meeting Departmental requirements" will be the responsibility of the bureau coordinators. Mr. Charles Hoyt, Bureau of Mines, will chair a working group consisting of the bureau coordinators to complete this item.

During the week of September 26, Charles Hoyt of the Bureau of Mines chaired two meetings of the Department of the Interior EROS Coordinators representing the five Departmental agencies that have been participants in the EROS program since its beginning in the late 1960's. The agencies were BLM, BIA, Reclamation, Fish and Wildlife Service and the National Park Service. As a result of these discussions the following observations, conclusions and recommendations are offered for consideration:

(1) Since the EROS program is within the USGS, it has focused primarily on USGS activities. Departmental agencies have been provided little, if any, opportunity for input regarding the review and guidance of the content, priorities and direction of EROS program activities. Therefore, EROS program as presently constituted and operated is not considered a Departmental program. (2) The existing EROS program generally does not foster, encourage or support operational Departmental missions. The emphasis on research and USGS activities by the EROS program has often discouraged basic operational efforts within the Department. However, the EROS program has played an important role in stimulating Departmental agencies to pursue the application of remote sensing technology in their activities.

(3) For the most part, the EROS program also receives high marks for its efforts in training programs at Sioux Falls, particularly in their BLM, FWS, Bureau of Reclamation and Bureau of Mines training efforts.

(4) Remote sensing is only one of many tools with which to gather information. Although LANDSAT is an important system for gathering data, it should not be viewed as a panacea for solving problems. Remote sensing systems should be assessed and integrated into total Departmental informational needs as required to carry out the multi-faceted missions of the Department.

(5) This leads to two recommendations that are interrelated.

Recommendations:

I. If the results of the EROS efforts are to be useful for departmental policy purposes, policy direction and guidance for the program should be shifted from the present science and R&D approach and placed at a higher managerial level where a more balanced operational orientation consistent with the Departmental mission can be achieved. A policy group, if possible at the Secretarial level, should be formed. It is suggested that the policy group be of modest size and include direction of the Sioux Falls EROS Data Center. The disciplines of the policy group should represent the various user agencies and include remote sensing expertise.

II. Further, it is recommended that the EROS policy guidance be integrated with a total Departmental resource information system as soon as practical. This is obviously a major managerial task and may go beyond the charter of our assessment of the EROS management structure. Nevertheless, the view is held by this working group.

Charles D. Hoyt	Bureau of Mines
Grover B. Torbert	Bureau of Land Management
Robert R. Ledzian	Bureau of Reclamation
Allan D. Marmelstein	Fish and Wildlife Service
Arthur M. Woll	Bureau of Indian Affairs
Theodore W. Sudia	National Park Service

Summary of Conclusions

1. Uses:

- o Operational uses of Landsat data are being incorporated into many Interior programs and programs of other agencies.
  - o Additional promising applications of Landsat have been explored that have potential for use in Interior and other agency programs.
  - o Other Government agencies, both Federal and State, are initiating uses of Landsat data.
  - o The mineral and petroleum industries are the largest private sector users of data. Most of the data (60 to 70%) used by the private sector is foreign coverage.

2. Apportioning Costs:

- o Budget and personnel allocations for the EROS Program should be considered on a Departmental basis.
- o Zero base budgeting for the EROS Program should be based on Departmental priorities rather than an indivudual bureau priority.

3. Future Space Technology:

- o Approved and planned space programs will produce data and technology that will be valuable to the Department.

- o A central focus for these activities, in addition to remote sensing, needs to be created in the Department. This focus can be created by upgrading EROS Program's management and scientific role.

- o Interior should be more assertive in defining future requirements for space technology.

4. International Roles:

   - o Interior is active in international cooperative programs.

   - o Landsat and communications satellites have a demonstrated capability for assisting foreign countries.

   - o Interior has been instrumental in developing policies for data availability related to Landsat. Interior should be more active in the forming of international space policy.

5. Departmental and Management Position of the EROS Program

ACCEPTANCE OF LANDSAT DATA

Assess acceptance of Landsat data in the routine activities of Federal, state, and local government, academia, and industry

Interior is a major source of remotely sensed Earth resource data from Landsat and other systems (through the EROS Data Center) and a major user of such data. Accordingly, we are prepared to comment on our experience in the use of Landsat data as an aid in fulfilling our Departmental missions, and on the types of users that obtain their data from the EROS Data Center.

Evidence of the usefulness of Landsat data outside of Interior can be found in a number of documents, such as the proceedings of the numerous symposia held around the world on this subject (see attached selected bibliography). Of particular note is a recent document prepared by the Office of Applications, National Aeronautics and Space Administration, entitled "A summary of the users perspective of Landsat-D and reference document of Landsat users." This document attempts to summarize the user experience with Landsat data of Federal, State/regional/local, private, and foreign users.

Use of Landsat data by the Department of the Interior

The Landsat satellite system has been providing data to Interior bureaus for research and development since its beginning in 1972. Several bureaus have demonstrated that the data can be used in their normal operations, and the Bureau of Reclamation and the Bureau of Land Management are implementing programs that depend on Landsat as a repetitive data source. The following paragraphs highlight some of the important applications. A more complete listing can be found in Table 1.

The Geological Survey, which has provided the scientific and technical leadership in the Department of the Interior through the EROS Program, uses Landsat data in a large number of research and investigative projects. These cover problems such as mineral resource investigation in Alaska, changing environmental conditions in wetlands, land use mapping, preparation of environmental impact statements, water resources exploration, and mapping of natural hazards. In particular, the work being done by the Topographic Division on mapping offshore reefs in shallow waters, the Geologic Division on merging geophysical and digital Landsat data to a common format, the Water Resources Division on assessing ground water potential in the upper midwest, and the Land Information and Analysis Office on mapping land use/land cover within the National Petroleum Reserve of Alaska, are among the examples illustrating the Geological Survey's commitment to integrate this technology into established resource mapping and assessment programs. In addition,

the Department's EROS Program, administered by the Geological Survey, provides training in Landsat data analysis methods to personnel from the other bureaus of the Department, as well as from other agencies.

The Bureau of Land Management has conducted sufficient research in Landsat applications for their missions to proceed with major investments in programs and systems to use Landsat to support their activities. BLM is participating with EROS and NASA in a major test of a Landsat-assisted system for inventorying and monitoring wildland vegetation on public lands. It is procuring a digital system for its Denver Service Center to support field activities in all offices. In addition, the BLM is (a) in the process of hiring one remote sensing specialist for each state office, three specialists for the Denver Service Center Office, and one specialist to be located at the EROS Data Center; (b) implementing a 3-year remote sensing training program available to all professional and technical personnel (approximately 200 people have participated in the courses given to date, which represents nearly 10% of BLM's professional and technical workforce); and (c) letting contracts with industry to obtain data analysis services associated with ongoing programs (e.g., California Conservation Desert Area Plan Project). Since the missions of BLM have been enlarged by legislative mandate from the traditional activities of rangeland management to much broader aspects of total land management, the need for cost effective and timely

analysis systems has led to the decision to build a Landsat-based analysis capability as part of the Bureau's operational information system.

The Bureau of Reclamation is developing a digital Landsat analysis system to use for mapping and monitoring of agricultural areas for irrigation water management. Studies recently have been conducted using digital remote sensing techniques for water resource inventory in the Columbia River Basin and riparian vegetation in the Lower Colorado River Basin. Personnel are being trained in the new techniques and will be capable of utilizing Landsat data for the bureau's irrigated land inventory.

The Bureau of Mines has had success in mapping clay mines in South Carolina with digital Landsat data, and is exploring the possibility of using it for monitoring land use changes caused by mining and reclamation of mined lands. A number of Bureau of Mines State Liaison Officers are being trained in analysis techniques so that they may aid State agencies in using Landsat.

The Fish and Wildlife Service is active in using Landsat digital data for baseline habitat mapping and monitoring effects of mining on wildlife habitat in the western energy lands. Landsat data are also being used for basic inventories in the National wetlands program and Landsat combined with meteorological

satellite data are used in Alaska for the National Wetlands Inventory and for monitoring freeze/thaw conditions in the Arctic breeding grounds of migratory waterfowl in order to predict waterfowl population. An aggressive training program in remote sensing for Fish and Wildlife personnel is in progress in which approximately 150 field personnel have participated. Demand for these courses is such that three additional sessions are scheduled for FY 1978.

Departmental bureaus have had sufficient experience in the use of Landsat to be convinced of its utility to their missions, to make major capital investments in training and equipment, and to prepare for its operational use. Continued availability of satellite data with improvements in the ground data-handling system will permit these organizations to continue to benefit from the previous research and capital investment, and will provide the Department with additional up-to-date information on which to base resource and environmental management decisions.

Table I: Current uses of Landsat data by USDI Bureaus

Geological Survey

- Digital enhancement and analysis of altered and potentially mineralized zones and altered areas.
- Monitoring snow cover accumulation, melt, and change in irrigation and hydroelectric catchments in the western United States and adjacent areas of Canada in order to contribute to predictive hydrologic models and runoff calculations.
- Assessment and monitoring of water turbidity, and algae blooms.
- Monitoring seasonal consistencies and variation in the Beaufort OCS sea ice.
- Contribute to land use/land cover (LUDA) and land use/land cover change detection mapping and statistical analysis of non-urban areas at scales of 1:250,000 and smaller.
- Mapping of flooded areas and shallow water features.
- Publication of Landsat image maps at 1:250,000, 1:500,000, and 1:1,000,000-scale of unmapped or poorly mapped regions of Antarctica in support of national and international research efforts.
- Distribution of Antarctic Landsat products to the 11 other nations signatory to the Antarctic Treaty in accordance with resolutions adopted by the Scientific Committee on Antarctic Research (SCAR).

Table I (Continued)

- o USGS Workshop on Landsat Mosaic Techniques being held in September for Latin American nationals in Panama at the request of IAGS.

- o Compilation of provisional Landsat planimetric and land use maps at 1:100,000-scale of the Federal Capital Territory of Nigeria - totally reimbursed.

- o Basic compilation of Landsat image products in support of ongoing USGS mineral resource mission in Saudi Arabia.

- o Under AID sponsorship and funding, compilation of Landsat image map of the Central African Empire (CFE) at 1:1,000,000-scale.

- o Under an AID agreement USGS will conduct a Landsat workshop in Morocco in November 1977 with possible follow on remote sensing cooperative programs.

Bureau of Land Management

- o Vegetation type and geologic mapping in Alaska, Arizona, Idaho, and California.

- o Study of salinity problem in upper reaches of the Colorado River.

- o Route selection for utility corridors.

- o Monitoring ephemeral rangelands for drought and overgrazed conditions.

Table I (Continued)

- o Assessment of vegetation types and meteorological conditions to predict fire-burn index.

- o Mapping extent of fire scars and rate of revegetation.

Bureau of Reclamation

- o Inventory of irrigated cropland, including acreage under irrigation and a breakdown by crop type.

- o Surface water inventory of the Playa Lakes in the Texas High Plains.

- o Water and wetland measurement to assess the amount of waterfowl habitat and the impact of irrigation.

- o Regional environmental surveys for preparation of environmental impact statements prior to project development.

- o Mapping the area extent of snow cover in major watersheds.

Table I (Continued)

Bureau of Mines

- Detection and monitoring of surface mining activities

Fish and Wildlife Service

- Vegetative cover typing as input to regional habitat mapping
- Wetlands inventory in Alaska
- Monitoring ice conditions in Arctic goose nesting grounds to aid in the prediction of waterfowl populations

Bureau of Indian Affairs

- Monitoring with Landsat to supplement and update the orthophoto coverage of Indian lands
- Mapping and classification of forest lands for the northwest Indian tribes to produce updated land-use plans

Mine Enforcement and Safety Administration

- Delineation of large (>10 km) lineaments on Landsat imagery with fracture sets and prediction of potential roof and face falls in 90 mining areas in the United States.

Landsat data demand and user profile

Photographic reproductions and magnetic computer tapes are processed and distributed by the EROS Data Center (EDC) to domestic and foreign users at prices commensurate with cost of reproducing these materials. As of June 30, 1977, there were more than 5.5 million images in the data base, including over one million frames of Landsat images and Landsat data in the form of computer-compatible tapes. Aerial and space imagery holdings increased at an average rate of about 40,000 frames per month, of which 25,000 were Landsat imagery.

The demand for Landsat data showed a marked increase in FY 1976--EDC distributed 26 percent more frames of Landsat imagery than in 1975, but in addition, sales of computer-compatible tapes increased from 729 to 2289, an increase of 213 percent. This indicates an increased trend toward the use of digital processing of Landsat data by users. Total demand for satellite and aircraft data has grown from $375,000 in FY 73 to $837,000 in FY 74, $1,610,000 in FY 75, $2,465,000 in FY 76, and a projected $2,700,000 in FY 77. Landsat data production has grown from $230,000 in FY 73 to a projected $1,566,000 in FY 77.

Among the users, private industry and the Federal Government currently comprise the largest single purchasers each with 29 percent of the total dollar value in FY 76; followed by foreign customers, 17 percent; NASA principal investigators, 5 percent; academia, individuals, and State and local government agencies accounted for the remainder (see Table II). Within the industrial group, the extractive industries (fuels/minerals) comprise the largest set of users. For example, an analysis in 1975 showed that from a Forbes list of 500 U.S. industries, 113 are energy related, and 81 of these have purchased data from the EROS Data Center. Thirty-four of the 81 energy-related industries showed a highly repetitive ordering pattern, either initiating new orders on approximately a monthly basis, or retaining standing orders for data as they become available.

Table II
User profile of orders for data
from the EROS Data Center in FY 77 (through June)

Industry	29%	Individual	8%
Federal government	29	Education	9
Foreign	17	State and local government	3
NASA principal investigators	5		

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Table II

Uses by Other Federal Agencies

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

October 7, 1977

OFFICE OF
RESEARCH AND DEVELOPMENT

SUBJECT: Uses of Landsat Data

FROM: A. C. Trakowski
Deputy Assistant Administrator
for Monitoring and Technical Support (RD-680)

TO: W. A. Radlinski
Chairman, Landsat-D FCCSET
Task Team on Ground Data Processing
U.S. Geological Survey
Reston, Virginia 22092

The following is a list of Landsat data applications currently being examined and evaluated by the Environmental Protection Agency, Office of Research and Development, as part of its remote sensing R&D program.

- Digital enhancement for analysis and montoring of water turbidity and algae blooms;
- Digital enhancement for first level analysis of land use;
- Analysis of vegetation stress due to air pollution;
- Inventory of agriculture for non-point pollution source modeling;
- Digital analysis of surface mining activities and environmental effects;
- Digital analysis of coastal zone characteristics and pollution effects;
- Digital analysis to determine the trophic condition of lakes.

Potential Uses of LANDSAT data by the Corps of Engineers

-Land cover classification for:

- -Input to hydrologic and hydraulic models
- -Input to environmental impact assessments
- -Input to regional habitat assessments
- -Input to site selection studies
- -Identifying and monitoring wetlands

-Geologic mapping for:

- -Location of construction materials
- -Site selection studies
- -Seismic risk studies

-Surface water mapping for:

- -Maintenance of the inventory of impoundments in support of a national program to assure safety of dams
- -Assessment of flooded areas

-Surveillance of rivers, estuaries, and coastal areas for:

- -Assessment and monitoring of turbidity
- -Assessment and monitoring of navigation channels
- -Monitoring coastal erosion and accretion
- -Monitoring ice conditions
- -Mapping of currents

Current Uses of Landsat Data by USDA Agencies

Forest Service

Forest Service efforts in the uses of Landsat data are in the realm of research and development exploratory and feasibility studies. Landsat data are not currently used to support operational Forest Service activities.

- To determine the potential accuracy of procedures incorporating Landsat and multi-stage estimates for obtaining Forest survey statistics (by counties) in Virginia and South Carolina.
- To describe Forest and chaparral fuels in southern California.
- To detect and evaluate gypsy moth defoliation in northeastern Forests.
- To identify host type and damage levels to Spruce Fir Forest in northern Maine resulting from Spruce budworm defoliation.
- To develop procedures for range biomass estimation, assessment of range readiness/utilization, and inventory in Texas and Colorado.
- To stratify dead timber concentrations in the National Forest of the Idaho Panhandle and western Montana.
- To determine favorable grizzly bear habitat in the wildlands of the Lolo National Forest, Montana.

- To evaluate Landsat analysis as a land management planning tool in Colorado and Alaska.

- To develop procedures for ADP analysis of Landsat data for type separability and a simulated inventory in 10 generalized continental ecosystems as represented by 60X60 KM Forest sites in the following locations:

  - Grand County, CO
  - Warren County, PA
  - St. Louis County, MN
  - Kershaw County, SC
  - San Duval County, NM
  - Ft. Yukon, AK
  - Weld County, CO
  - Grays Harbor County, WA
  - Washington County, MO

- To determine the feasibility of augmenting established Forest survey procedures with Landsat ADP analyses in the Olympic inventory unit of western Washington.

Foreign Agricultural Service (FAS)

- Quasi-operational test of ability to predict foreign wheat production, using Landsat and meteorological data. (LACIE)

Agricultural Research Service

- Quantification of stresses (insects, diseases, high and low temperatures, salinity, drought) in relation to production
- Estimates of leaf area index, green biomass, vegetative cover, and plant population
- Thermal and water content maps
- Vegetation damage caused by smog, SO_2, foluride, ozone, and other atmospheric pollutants
- Occurrence and spread of weeds, and distribution of host plants for insect and disease vectors
- Detection of deficient and toxic concentrations of soil constituents (heavy metals, major and minor nutrients, salinity)
- Documentation of spread of root and foliar diseases and effects of nematode populations
- Rangeland management--condition, animal carrying capacity, brush infestation, vegetation resources, natural plant communities, brush control effectiveness and reinfestation
- Microclimate surveys (freezes, cold and warm spots) in fruit, specialty crop, and high value vegetable crop production areas and assessment of freeze damage

- Phenologic stages of crops to improve timing of defoliants and other harvest aid chemicals

- Measure damage done by insects such as white grubs on grasses, cereal leaf beetle, greenbugs on small grain, and the range caterpillar

- Assess extent of drought and relative water-holding capacity of the soil

- Planting date advisories

- Evapotranspiration modeling as affected by plant cover, plant-available water in the soil profile, and the aerial environment including solar radiation reaching the ground

- Synoptic soil water contents and aridity indexes

- Scheduling irrigations

- Irrigation and soil water supply estimates from snow cover, amount of water in impoundments, recharge areas, water table conditions, and rainfall distribution

- Winter kill of crops (small grains, alfalfa, etc.) in relation to snow cover and meteorological conditions

- Estimates of production losses due to insects, weeds, plant diseases, and nematodes

Soil Conservation Service

° Prepared a photo mosaic of Landsat imagery for U.S. contiguous States under contract for NASA which was then reproduced for public sale cooperatively with the U.S. Geological Survey. A similar mosaic for Alaska was prepared with SCS and State cost sharing.

° Image bases for preparing small scale General Soil Maps, and for revising Major Land Resource Areas of the USA.

° Testing use of digital analysis methods for improving detailed soil mapping techniques used in the National Cooperative Soil Survey.

° Monitoring snow line location and movement to improve water yield models and irrigation water supply forecasting procedures used in eleven western States.

° Reindeer range survey and identification of range sites in Alaska.

° Evaluating present vegetation and land use for river basin studies.

Statistical Reporting Service

° Landsat image products are used in constructing land area sampling frames that identify the units for enumeration which supply the Agency with its major source of input for crop and livestock estimating programs. Our present activity is a demonstration in one State. If the demonstration is successful, there will be a potential to obtain image products for three to five States for new frame construction each year plus acreage to update existing

frames in other States. The use of Landsat image product is similar to that for a photo interpretative process using conventional aerial photography.

° Digital data are used in research investigations of the potential of Landsat to identify areas of improtant agricultural land use for small land unit areas (counties or aggregates of contiguous counties or production areas of comparable size). Landsat CCT's are used as ancillary data with ground enumerated data from sample units selected from the land area sampling frame. In the present research operation no more than about fifty scenes are being processed annually. If at a future point the research changes to a test or operational program the number of tapes necessary for processing could increase to several hundred. If there is to be potential operational value it will be necessary to receive CCT's within about a five day time interval from the time of acquisition.

Table III

Uses by States

Examples of uses of Landsat data by States

ALASKA

The Geophysical Institute of the University of Alaska made a mosaic of Alaska at the request of the Alaska State Geological Survey to match new geologic maps at a scale of 1:1,000,000

The Federal-State Land Use Planning Commission will make regional mosaics at a 1:500,000-scale from black and white prints

BLM and NASA are cooperating on a wildland inventory of the 2-million acre Denali Test Site. Landsat data are also being used to map structural features as part of an Applications Systems Verification Test (ASVT).

Vegetation of the National Petroleum Reserve in Alaska is being mapped as part of an Environmental Impact Statement concerning the 10-image area.

Landsat images were used to study icings along the trans-Alaska pipeline route to anticipate problems such as flooding and erosion near the pipeline stations, roads, and other facilities (USGS Prof. Paper 979).

USGS geologists are mapping linear features in Alaska to analyze tectonic developments which may indicate the location of mineralized areas.

USGS scientists are studying ice dynamics in the Beaufort Sea. Artificial islands, properly placed, may be used to modify the zonation and make the Arctic offshore environment less hostile.

BLM used satellite imagery to assess forest fire damage and allocate fire protection measures to the approximately 500 forest fires occurring in July and August.

Fish and Wildlife Service monitored moose and caribou habitat.

ARIZONA

Arizona Resources Information System (ARIS) has taken over the former EROS Program Applications Assistance Facility in Phoenix.

Mosaics of the State of Arizona at a scale of 1:500,000, one in black and white and one in sepia with cultural features, were made by USGS for ARIS, and used as a base for mapping snow cover, remote subdivisions, and weather information.

A mosaic of the Phoenix quadrangle was made by USGS at 1:250,000 scale in sepia.

Satellite imagery and data relayed by satellites from remote locations are used to map snow lines and estimate snow melt for managing six reservoirs of the Salt and Verde Rivers.

CALIFORNIA

CALSCAN, a computerized land use classification system developed by the University of California to analyze Landsat data, is being used by the Palo Verde Irrigation District and the Colorado River Indian Reservation near Blythe, California.

EROS and BLM are cooperating in a project of land systems mapping in the Mojave desert using remote terminals to an interactive computer system at the EROS Data Center and analysis on the Image-100.

Sierra Cooperative Pilot Project - The satellite data collection system is being used to collect hydrometeorological data from areas in the Sierra Nevada Mountains in a Bureau of Reclamation study of severe winter environment.

An oil seep in the Santa Barbara channel is detectable on Landsat imagery that has been photo-optically enhanced or computer processed. Such a detection capability is the subject of experiments to develop a potential tool for coastal zone petroleum exploration.

COLORADO

Bureau of Reclamation is conducting an inventory of land use features of the Colorado River system using computerized methods of image analysis. Included are a land use and hydrology study of the San Luis Valley closed basin and the Grand Valley project in Grand Junction.

DELAWARE

Scientists at the University of Delaware are mapping wetlands and studying estuaries and coastal pollutants from satellite images for the State Department of Natural Resources and Environmental Control.

DISTRICT OF COLUMBIA	Precision processed and enhanced image maps of the Upper Chesapeake Bay have been made by USGS and IBM at 1:500,000 and 1:250,000 scales.
	A three-image mosaic of the area depicted by Landsat in February 1977 showing maximum ice is being made by USGS as an example of mapping a temporal phenomenon.
FLORIDA	Digital analysis of Landsat imagery is being tested as a monitoring and classifying system for phosphate mining by EROS and Bureau of Mines cooperating with Florida State officials.
	USGS made a color mosaic of the State at 1:500,000 scale and 11 image maps of nominal scenes. The image map of the Florida Keys was enhanced to show the topography in the shallow seas.
	Landsat imagery and satellite relayed data are used for water management in the Everglades, a rather inaccessible area where land surface profiles are not available and water does not flow in channels making it difficult to measure.
GREAT LAKES	ICEWARN is a NASA ASVT in cooperation with U.S. Coast Guard and NOAA to monitor ice in the Great Lakes as an aid to navigation.
	Landsat-2 imagery is being used to study eutrophication in the Great Lakes basin.
	Sediment plumes and beach erosion in Lake Ontario are being monitored with Landsat.
GEORGIA	USGS made a color mosaic of the State for the State Geologist for use in regional geologic studies.
	Bureau of Mines is monitoring surface mining and land reclamation in the kaolin mining district using Landsat computer compatible tapes.
	The Atlanta Regional Commission and the EROS Data Center made a study of land use in a 7-county area including Atlanta. Temporal overlays, made by computer techniques from Landsat images of different dates, were analyzed to detect changes.

IDAHO

As one of the States in the Pacific Northwest Regional Commission, Idaho is involved in the following projects using Landsat data:

Idaho Department of Water Resources is conducting an inventory of 4 million acres of irrigated cropland on the Snake River.

The Agriculture Department is evaluating the crop loss from the failure of the Teton Dam.

The Department of Fish and Game and the Department of Lands are monitoring rangeland to assess conditions and determine the capacity for production of game animals.

Department of Public Lands is conducting a forest inventory of the State.

The Ada Council of Governments is making a study of Boise to study urban growth to be used by the Bureau of State Planning and Community Affairs.

USGS produced an Environmental Impact Statement on phosphate mining in Maybe Canyon.

IOWA

The Iowa Geological Survey Remote Sensing Laboratory produced a land use map of the State using Landsat data.

A land classification of south central Iowa from computer enhanced Landsat images was made at the EROS Data Center.

INDIANA/KENTUCKY

The Southwest Indiana and Kentucky Regional Council of Governments did a regional land use classification from computer-processed Landsat data.

Eastern Kentucky University made an inventory of surface mined land in eastern Kentucky from Landsat data.

KANSAS

The University of Kansas made a land use map of the State with Landsat data.

LOUISIANA	A NASA ASVT with the Corps of Engineers developed an Environmental Information System for the State.
	The Department of Fish and Wildlife participated in a workshop at the EROS Applications Assistance Facility at Bay St. Louis, Mississippi.
MIDWEST	A 54-image springtime mosaic of the area was made at the EROS Data Center showing glacial features too large to see from aircraft photographs. Possible sites for locating ground water or sand and gravel deposits were indicated.
MISSISSIPPI	The Mississippi River flood of 1973 was mapped using Landsat imagery.
	A Natural Resource Information System was devised by the State of Mississippi and NASA as an ASVT.
MONTANA	The Bureau of Reclamation used the Data Collection System to observe cloud systems for the purpose of weather modification in the High Plains Cooperative Program.
NATIONAL	A Wetlands Inventory is being developed by USGS and FWS comparing data by ecosystem, physiographic region, and wetland class.
NEBRASKA	Center pivot irrigation systems are inventoried using Landsat computer compatible tapes for the Nebraska Department of Commerce.
NEW MEXICO	A vegetation and land use map is being made by the New Mexico Bureau of Mines and Mineral Resources.
	Bureau of Mines (DOI) with several State organizations are classifying mines and reclaimed areas, measuring total mined areas at Navajo and McKinley coal mines, and inventorying waste dumps and ponds at potash mining areas.
NEW YORK	Scientists at Cornell University are studying aquatic vegetation and dam safety inspection, funded by the Office of Water Resources Technology.

Lineaments in Fulton County seen on Landsat imagery are being examined to find ground water.

The New York State Museum and Science Service and the New York Education Department are conducting a study of the evidence for contemporary doming of the Adirondack Mountains for implications of regional tectonics.

NORTH CAROLINA

The National Park Service is using the Data Collection System to study water quality parameters in the Great Smokies.

NORTH DAKOTA

Bendix Corporation is processing Landsat data of Devil's Lake basin, including a set of overlays at 1:250,000 scale, for the State Water Commission.

The Regional Environmental Assessment Program contracted Bendix to map the State using the MDAS system to tabulate acreage to county and township levels.

The Northern Prairie Wildlife Research Center with FWS is conducting studies of waterfowl habitat.

The Basic Electric Power Cooperative in Bismarck uses Landsat data to route high voltage transmission lines.

A study of the Red River flood in North Dakota and Minnesota was made at the EROS Data Center.

OREGON

FWS and EROS are cooperating on a project to monitor kelp and eelgrass in Oregon and Washington coastal areas, using Landsat digital data and the facilities of the Data Analysis Laboratory at the EROS Data Center.

As a member of the Pacific Northwest Regional Commission, Oregon is using Landsat data in the following projects:

The Water Resources Department is conducting an inventory of 280,000 acres of irrigated land in the Klamath River basin using visual methods of data interpretation. In addition, water levels in reservoirs are monitored during the growing season as drawdown occurs.

Another agricultural project is to monitor the spread of tansy ragwort, a weed which is toxic to livestock and also destroys desirable forage species.

The Columbia Region Association of Governments and the State Department of Transportation are cooperating in an urban land use inventory of the Portland area.

The forests of Douglas County are being classified according to ownership, species, and age of trees, and extent of clearcutting.

A demonstration project in the Silver Lake range is assessing the habitat for mule deer.

SOUTH CAROLINA

Bureau of Mines is monitoring surface kaolin mines in Aiken County to aid in regulation of mining activities by the South Carolina Land Resources Commission.

SOUTH DAKOTA

The EROS Data Center is aiding the State Planning Bureau in a State-wide land use inventory to be incorporated into a geographic system.

The South Dakota State Bureau of Reclamation is using Landsat data to detect near surface ground water on irrigated lands.

TENNESSEE

Landsat images were used to prepare 15 maps of the New River basin (1000 km^2 area) to evaluate the impact of surface mining as part of a 5-year energy development program.

TEXAS

Levels of playa lakes in the southern High Plains of Texas and New Mexico were monitored on Landsat imagery.

UTAH

The Intermountain Forest Range Experiment Station in Ogden is being used as a site for a study of desertification using Landsat imagery.

VIRGINIA

The Great Dismal Swamp National Wildlife Refuge is cooperating with USGS and NASA in studying the hydrology and mapping the vegetation of the area to acquire a data base for wetlands management.

WASHINGTON

As a member of the Pacific Northwest Regional Commission, the State is participating in the following projects using Landsat data:

The Department of Natural Resources is making an inventory of State-owned lands and an estimate of forest productivity.

The Department of Game is inventorying wildlife habitats in the Umatilla National Forest.

Land use and land cover maps of the 8,000 square mile Puget Sound area are being made with 10 user agencies involved.

A land use study of Tacoma/Pierce County is also being conducted.

Washington and Oregon are cooperating in a Coastal Zone Management Project.

WYOMING

EROS, Bureau of Land Management, and IBM cooperated in producing a digitally enhanced mosaic of the Powder River basin as an aid to monitoring rangeland.

Landsat data demand and user profile

Photographic reproductions and magnetic computer tapes are processed and distributed by the EROS Data Center (EDC) to domestic and foreign users at prices commensurate with cost of reproducing these materials. As of June 30, 1977, there were more than 5.5 million images in the data base, including over one million frames of Landsat images and Landsat data in the form of computer-compatible tapes. Aerial and space imagery holdings increased at an average rate of about 40,000 frames per month, of which 25,000 were Landsat imagery.

The demand for Landsat data showed a marked increase in FY 1976--EDC distributed 26 percent more frames of Landsat imagery than in 1975, but in addition, sales of computer-compatible tapes increased from 729 to 2289, an increase of 213 percent. This indicates an increased trend toward the use of digital processing of Landsat data by users. Total demand for satellite and aircraft data has grown from $375,000 in FY 73 to $837,000 in FY 74, $1,610,000 in FY 75, $2,465,000 in FY 76, and a projected $2,700,000 in FY 77. Landsat data production has grown from $230,000 in FY 73 to a projected $1,566,000 in FY 77.

Among the users, private industry and the Federal Government currently comprise the largest single purchasers each with 29 percent of the total dollar value in FY 76; followed by foreign customers, 17 percent; NASA principal investigators, 5 percent; academia, individuals, and State and local government agencies accounted for the remainder (see Table IV). Within the industrial group, the extractive industries (fuels/minerals) comprise the largest set of users. For example, an analysis in 1975 showed that from a Forbes list of 500 U.S. industries, 113 are energy related, and 81 of these have purchased data from the EROS Data Center. Thirty-four of the 81 energy-related industries showed a highly repetitive ordering pattern, either initiating new orders on approximately a monthly basis, or retaining standing orders for data as they become available.

Table 1V
User profile of orders for data
from the EROS Data Center in FY 77 (through June)

Industry	29%	Individual	8%
Federal government	29	Education	9
Foreign	17	State and local government	3
NASA principal investigators	5		

APPORTIONING COSTS

Merits of Apportioning Costs (for Space Technology Activities)
among Various Bureaus of the Department and
Possible Methods of Funding

Types of Costs:

Two types of functions and associated costs have to be considered for space technology activities within the Department. These are:

1) costs for centralized functions that serve the Department, such as (a) long-lead (3-5 years) applications research, and (b) operation of the EROS Data Center and specific costs for purchase and operation by the Center of major systems that may be related to either experiments or operational programs; and

2) costs for data use functions that relate to supporting operational activities within individual bureaus.

Considerations of how to apportion costs in the following discussion is restricted to centralized Departmental functions. Each bureau would support its own data use activities, including contract services, special facilities, and in-house analysis efforts. These bureau budget items may or may not be identified as space technology activities because data acquired from space is a tool, not a program objective in itself.

Discussion of Approaches:

Apportioning costs for centralized functions to the various bureaus after appropriations have been made would require reprograming actions and could severely impact other programs that have been justified to the Department, Office of Management and Budget, and the Congress. In addition to the impacts on other programs, most reprograming requires extensive administrative effort to obtain approval from the Administration and the Congress. Reprograming actions can also compromise future year budget justifications for critical activities. Reprograming of appropriated funds should only be used to take care of emergency situations.

Apportioning costs to various bureaus during the budget preparation cycle by the Department would be a possible mechanism to obtain funding for the centralized functions. One approach would be to have each bureau include a line item in their budget request to cover their pro-rated costs of centralized functions of the program. This approach would be clumsy from an administrative sense and would run the risk of approval of portions of the funding and denial of other portions. It would be difficult to plan for and manage the centralized functions of a program that depended on the uncertainty of several appropriation sources.

Another approach to apportioning costs to the bureaus for centralized functions would be to reduce the budget ceiling of the bureaus by a pro-rated amount and use this portion of the budget ceiling to support the appropriation request as a single line item. In addition, each bureau would need to budget for its own data use. This approach would "spread the pain" for funding centralized functions in an obvious way and make it possible to plan and manage the space technology activities consistent

with the appropriations process, although some risks could be expected from reluctance of bureaus to identify or to participate in space technology applications for fear of increasing their assessment if the pro-rating formula is based on the uses that are being made within the bureau. An "across the board" pro-rating based on total appropriations would remove this risk, but would have a nonequitable impact on some bureaus that have minimal applications for space technology. The fact that a specific amount of bureau budget ceiling was identified, even in an across-the-board assessment, would tend to cause resentment and criticism of the program that would discourage participation.

A less visible method of apportioning budget ceiling for centralized activities would be to provide a specific budget target to the program much like the budget for any bureau. In effect, this would be equivalent to an across-the-board assessment of budget ceiling based on total appropriations but would not identify the specific impacts on any bureau. The justification and final determination of the budget request would conform to other zero base budgeting procedures and Departmental priorities could be assessed directly.

The least satisfactory budgetary approach would be to include centralized activities in the budget ceiling of any single bureau. The impact on other programs in that bureau would be disproportionately great and the resources needed to implement new capabilities would be difficult to obtain. Special difficulties arise when the new capabilities are not closely related to the traditional responsibilities of the bureau that would be providing the funding.

Recommendation:

Provide budget ceiling for centralized space technology functions that serve the whole Department as a single budget item and justify the funding levels through the zero base budgeting process; each bureau would seek their own appropriations for use of the data to support their ongoing programs (see Table 1).

Table 1

Interior Departmental

functions using space technology

Overall Program Functions:

To be budgeted as a single Departmental item

- Operation of EROS Data Center
- Purchase of special centralized data analysis systems
- Coordination and planning with NASA and other agencies
- Conduct of specific spaceflight operations
- Initiate new uses of space technology to meet Departmental needs

Examples of program functions of specific bureaus that use space data to perform their missions:

Funded by Bureaus

- Geological Survey
  - Geologic mapping and exploration
  - Topographic mapping
  - Water surveys
  - Land use mapping
- Bureau of Land Management
  - Rangeland surveys
- Bureau of Reclamation
  - Irrigated land surveys
  - Snowpack monitoring
- Trust Territories and Bureau of Indian Affairs
  - Local communications capabilities
  - Natural resource management

To be budgeted by each Bureau as required

VALUE OF SPACE TECHNOLOGY

Assessment of the Nature and Value of All Space Technology (in addition to Landsat) to the Department over the Next Ten Years

Introduction

The types of space technology that are of direct interest to the Department in the near (next 10 years) future fall into four major classes. These classes are:

1. Remote sensing
2. Measurement of geophysical parameters
3. Precise distance measurements
4. Communications

In addition, there are "spin off" capabilities that can have direct uses to Departmental programs such as improved inertial systems that have potential for improved aircraft measuring systems; small, relatively low-cost computer systems that serve a large variety of specialized Departmental programs; and improved safety standards and procedures for petroleum production on the Outer Continental Shelf and onshore. Spin offs are not predictable. They require the availability of technology, familiarity with the technology that is available, and individuals with enough imagination and perception to see how technology can be applied in new ways. Departmental participation in advanced technology areas will be essential to make spin off benefits occur instead of waiting to see if they occur.

Remote Sensing

The Landsat program has received more attention than several other programs and is treated in other discussions. Other space remote sensing programs that are of importance to Interior are discussed in this section.

NOAA Meteorological Satellites (operational program):

While primarily intended for atmospheric study, weather prediction and oceanographic data acquisition, the operational NOAA polar orbiting satellites and the Geostationary Operational Environmental Satellites (GOES), operated by NOAA, form sources of data that are being used by the Department. The costs to Interior are minimal, since the system is funded and operated by another agency. Uses of data from these satellites include:

1. Mapping of the extent of snow cover using the relatively low resolution but frequent coverage provided by these satellites.

2. Observing cloud patterns to determine the proper times for cloud seeding operations.

3. Documenting ocean temperature and current patterns in the Outer Continental Shelf and in island areas such as the Trust Territories for environmental studies and safety considerations.

4. Sea ice monitoring to improve our understanding of environmental conditions and engineering problems in the Arctic.

Defense Meteorological Satellites (DOD operational program):

The Defense Meteorological Satellite program consists of polar-orbiting satellites with visible and thermal infrared bands. Resolution is higher than the civil counterpart NOAA satellites and world coverage is more frequent. Difficulties in data use are related to timeliness of data availability, types of data that are available, and calibration of the data. Photographic copies of the data are available through the University of Wisconsin. Digital tape data are not available. The thermal infrared channel has an automatic gain control that limits its scientific use. Potential uses of interest to Interior for these satellites include:

1. Monitoring of locations where gas is being flared on a worldwide basis.

2. Energy consumption and changes in energy consumption with time in urban areas of the United States.

Nimbus-G (approved NASA research mission, launch date 1978):

Nimbus-G is the last of a series of satellites devoted to research in uses of space for meteorological research. The primary objectives of Nimbus-G are experiments in the use of satellites for oceanographic and atmospheric physics. The Ocean Color Scanner to be flown on Nimbus-G will provide information on water penetration and bio-productivity of the ocean. Items of interest to Interior include:

1. The effects of human activity on bio-productivity of the Outer Continental Shelf.

2. Low spatial resolution experiments in mapping and location of shallow sea features within the 200-mile limit and in the Trust Territories.

Heat Capacity Mapping Mission (HCMM) (approved NASA research mission, launch date 1978):

This NASA-sponsored Applications Explorer Mission (AEM) will be a first attempt at acquisition of thermal infrared data at optimum times for data collection in early afternoon and after midnight. Purposes for the mission are primarily directed at research and not in support of operational programs. Interior will have some interest, in a research sense, in:

1. Measurement of thermal inertia of rock materials for discriminating rock types.

2. Study of thermal distributions of the surface of larger water bodies.

3. Estimating soil moisture and its relation to water demands and productivity of vegetation on the public lands.

Seasat-A (approved NASA research mission, launch date 1978):

A Synthetic Aperture Radar (SAR) and a Radar Altimeter are planned for Seasat-A. The SAR is of special interest to Interior because, together with the Radar Altimeter, it will have the capability to produce ocean wave spectra that are important to determine engineering specifications and design for structures in the Outer Continental Shelf and other coastal engineering problems.

In addition, the SAR instrument will be capable of providing all weather images of land areas. The pixel size of SAR will be 20 meters as compared to the 30 meters for the thematic mapper or 80 meters for the multispectral scanner on Landsat-D. Departmental uses of data from Seasat-A and similarly configured satellites include:

1. Determination of two-dimensional wave spectra for coastal and Outer Continental Shelf engineering specifications.
2. Measurement, year around, of sea ice distributions in the Arctic.
3. All weather mapping of continental surface features.
4. Availability of higher resolution data for use with the multispectral data available from Landsat.
5. A spectral band that relates to surface roughness and dielectric constants of surface materials.
6. Monitoring freeze/thaw conditions in Arctic geese nesting grounds.

Large Format Camera (under consideration by NASA for use on space shuttle or as a free flyer):

This camera would be an instrument facility for use on the shuttle or a free flying spacecraft to be serviced by the shuttle. The camera would be capable of acquiring photography of specific areas with spatial resolutions of about 10 meters in black and white, color, or color infrared. Stereographic capability would be available by obtaining photography with adequate overlap. Interior uses include:

1. Topographic mapping,
2. Geologic interpretations.

Stereosat (under consideration by NASA for a new start in 1979 with launch in 1981):

The objective of this mission is to obtain stereographic coverage of the world with about 20 meter resolution. The data would be adequate for interpretation of many geologic features, but would not be of sufficient quality for topographic mapping. Interior interests would be increased if the stability of the spacecraft and swath width were increased enough to make the data useful for automated topographic mapping. Interior interests are:

1. Geologic interpretations

2. Topographic mapping of high relief remote areas if some improvements are introduced into the system.

Operational Earth Resources Systems (not an official program):

Other than a joint study conducted by NASA and Interior in 1972 - 73, little detailed work has been done on defining all of the parameters that should be included in an operational earth resources satellite system. Data availability is limited to a variety of experimental programs. Uses of data are developing within and outside the Department. Some relatively new technology developments such as linear array detectors offer promise for more efficient data acquisition systems, simplifications in data processing, and improved procedures for data use. Interior should continue to play an active role in definition of the appropriate systems to be considered for future operational use.

Measurement of Geophysical Parameters

Space systems have already demonstrated significant capabilities for obtaining improved models of the geoid and for making global magnetic measurements. In addition, the ability to monitor polar motions and some suggestions of relations between polar motions to large earthquakes offers research possibilities for the future.

GEOS 1, 2, and 3 (experimental NASA satellites in orbit):

GEOS-1 and -2 carried corner reflectors for laser ranging from ground stations and used electronic tracking. GEOS-3 also carries a radar altimeter with an accuracy of about 1 meter over water. These satellites have made it possible to refine our knowledge of the shape of the geoid from errors of the order of 100 meters to an accuracy of about 10 meters. GEOS-3 should provide data to produce a geoid with an accuracy of about 1 meter. The importance to Interior is:

1. Improved geoids make it possible to revise the datum on which maps are based.

2. Improved geoidal information leads to improved gravity models that are needed to interpret gravity measurements for geophysical studies of the structure of the Earth and to arrive at new concepts to determine origin and location of mineral deposits in the Earth's crust.

Seasat Altimeter (approved NASA research mission, launch date 1978):

A radar altimeter on Seasat-A will have a vertical resolution of less than 30 cm. A related instrument on Skylab produced data over oceans that showed the effect of gravity anomalies caused by structural features such as oceanic trenches and sea mounts. Other uses for the altimeter include study of ocean currents and measurement of ice elevations in Antarctica. Applications to Interior programs include:

1. Determination of large gravity anomalies in oceanic regions as an aid to interpretation of crustal structures.

2. Measurement of ice elevations in Antarctica.

Magsat (approved NASA mission, launch date 1979):

The Magsat mission has been defined based on experience in the analysis data from the Polar Orbiting Geophysical Observatory (POGO) series of U.S. satellites and from the experience gained from the USSR Cosmos 49 satellite. Improvements over previous data acquisition will include a lower orbit for greater spatial resolution of the data, higher sensitivity of the scalar magnetometer, and a vector magnetometer. The mission is expected to last a few months. A complete, worldwide, set of measurements is to be obtained during this time. Departmental uses of the data will be:

1. Revision of the world magnetic charts

2. Development of a magnetic field model

3. Delineation of large magnetic anomalies that are related to major crustal and upper mantle structures, information of direct importance in the search for new mineral deposits.

Future Magnetic Missions (under study):

The magnetic field of the Earth is one of the most rapidly changing geologic phenomena. Magnetic charts should be revised at 5-year intervals. Methods of making the measurements that are needed in the future are under study. Some possibilities include towing of a tethered instrument package from the space shuttle or using a long-life free-flying satellite that would be placed in a high orbit most of the time, but lowered at 5-year intervals to make the detailed measurements. Departmental uses would be:

1. Updating world magnetic charts

2. Revising magnetic field models

3. More detail on magnetic anomalies could be determined if greater sensitivity and improved spatial resolution can be obtained in the future

4. The time sequence of reliable, consistent magnetic field models will be of significant value in understanding the mechanism for the source of the magnetic field and the dynamics of the Earth's fluid core

Gravity Gradient Missions (under study):

Some consideration has been given to measurement of gravity gradients on a global basis from space. Accuracies of available techniques and minimal requirements for data of the accuracies that could be obtained with state-of-the-art methods do not make this type of mission very attractive at the present time, although future improvements in measurement capability may make the methods more attractive to Interior programs.

Precise Distance Measurements

Two methods of using space technology for precise distance measurements have been studied and verified through experiments. These methods use laser ranging and very long baseline interferometry (VLBI). Laser ranging uses a powerful laser that sends a pulse to a distant corner reflector and then receives the returned pulse through a telescope that is aligned with the laser. Precisions of less than 10 cm over inter-continental distances have been demonstrated. Precisions between 2.5 and 5 cm appear possible in the immediate future. The VLBI technique uses 2 or more receiving stations to observe distant radio stars. The wave characteristics of these radio signals are compared and timed accurately to make the distance calculations. Precisions of about 10 cm have been demonstrated.

Laser Geodynamic Satellite - LAGEOS (NASA satellite in orbit):

This satellite consists of a sphere covered with a uniform distribution of corner reflectors. Ground based laser and receiver systems measure the distances to the satellite as it passes over in its orbit. These measurements provide the data to determine the distances between the ground stations to precisions of a few centimeters. Repeated measurements, at yearly intervals, from the same locations can provide direct information related to crustal strain accumulation and rates of continental movements. Uses within Interior are:

1. Regional strain measurements that will assist in earthquake prediction.

2. Establishing Geodetic control in remote areas.

Shuttle Laser Experiments (under study):

Laser ranging can also be accomplished from a space vehicle with the corner reflectors placed on the ground. This approach is attractive when a relatively dense network (spacing of 10 - 30 km) of measurement points over distances of a few hundred kilometers is needed. An experiment using a laser and receiver on the Space Shuttle and corner reflectors in the vicinity of the San Andreas fault is being considered. Measurements of this type will be useful to Interior for:

1. Improving methods of earthquake prediction.

2. Measurement of subsidence or uplift over large areas.

Very Long Baseline Interferometry - VLBI (Experimental demonstration stage)

The fact that very long baselines can be measured using radio stars as sources does not offer any immediate benefits to Interior programs. At the present time, the measurements require large tracking stations with specialized equipment. Measurements are expensive in terms of equipment and data reduction. Studies are in progress to see if lower costs and more portable equipment can be used to make these measurements. It is doubtful that VLBI will be cost competitive with laser ranging for distance measurements. The possibility exists that VLBI may be the most efficient method of measuring polar motions. The requirements of these measurements for Interior programs such as earthquake prediction need more study.

High Data Rate Communications (available commercially but not being used)

A major weakness in the current Landsat program is the time required to obtain data products. The processing systems at the NASA Goddard Space Flight Center (GSFC) and at Interior's EROS Data Center (EDC) are being upgraded to provide faster throughput and higher quality data products by mid-1978. The time required for transportation of magnetic tape data from Gillmore Creek, Alaska, and Goldstone, California, to GSFC for initial processing and then shipment to EDC will become a major factor in the time required between the acquisition of data by Landsat and the availability of data to users. This problem can be solved through the use of Domestic Communications Satellites (DOMSAT). Advantages to Interior to using DOMSAT would be:

1. Data could be obtained and made available to the user by EDC on a regular schedule within 24 to 48 hours of its acquisition by the satellite;

2. Selected portions of the data could be retransmitted to users that have near real-time requirements.

3. Costs of field operations for data collection can be reduced;

4. Measurement stations can be placed in locations where logistics are difficult because frequent servicing is not required;

5. The reliability of DCP's has been excellent and will probably improve in the future.

Intermediate Data Rates - (voice and video)

Satellites for video and voice communications are used internationally through the Intelsat systems. In general, these systems require expensive ground receiving terminals that would be difficult to justify for remote areas. Experiments have been conducted using the Applications Technology Satellite (ATS)-6 for communications to remote areas with lower cost ground stations. These experiments were carried out in the western States, Alaska, India, and in a number of other countries during times when the satellite was being repositioned in its geostationary orbit. Similar experiments are being conducted with the Canadian Technology Satellite (CTS). Use of these experimental and future operational capabilities can be of significant value to the Department for serving remote areas in the Western States' Indian tribes, Alaska, and the Trust Territories for:

1. Educational programs

2. Medical training and consultation

3. Privacy in voice communications

4. Teleconferencing that has the potential of reducing travel requirements and earlier solution of important problems

Communications

Space communication needs of the Department range from low data rates used for data collection platforms to intermediate data rates for voice and video transmission to high data rates needed to transmit remotely sensed data from one location to another. Capabilities to accomplish all of these functions are in existence or have been demonstrated.

Data Collection Platforms - DCP (operational demonstrations in progress)

A series of data collection experiments have been conducted during the past decade. Early experiments required expensive ground stations to communicate through satellites. With the launch of Landsat-1 (ERTS-1), it became possible to deploy large numbers of low cost DCP's that used the orbiting spacecraft to relay data to a central collection facility. These experiments demonstrated the reliability and economy of this approach. The NOAA operated GOES satellites have an operational capability to relay data from DCP's to a central location. A demonstration project, using commercial communications satellites for data collection will be implemented in 1977. The experiences gained from using the NOAA and commercial systems will form the basis for decisions on the method of future deployment of DCP's. Advantages to the Department from the use of DCP's include:

1. Rapid availability of data from remote, unmanned data collection locations such as stream gauges, water quality monitors, seismic event counters, tiltimeters, meteorological stations, and snow-depth measuring devices;
2. Data is available in digital form which reduces manpower requirements for interpretations prior to entry into data bases;

INTERNATIONAL OBLIGATIONS

Describe present international obligations and possible future departmental roles in systems with global capabilities

At present, the Department of the Interior is heavily involved internationally with the use of remote sensing technology (see Table 1). A large portion of these activities are being performed by personnel of the Geological Survey, which has also provided the Departmental technical leadership for domestic applications.

There is ample precedent for Departmental international activities involving remote sensing from space. For example, for a number of years it has been our national policy to disseminate knowledge on the use of remote sensing technology to interested foreign governments. This policy was enunciated by the President before the United Nations on September 18, 1969, where he stated "this program (Earth Resources Satellites) will be dedicated to produce information not only for the United States, but also for the world community," and "that we would equitably share knowledge derived from observations of our Earth derived from space."

On August 11, 1975, the Secretary expanded on this policy; he stated ". . . while we believe that knowledge of the Earth and its environment gained from outer space should be broadly shared, we recognize that this must be accompanied by efforts to insure that all countries will fully understand the significance of this new knowledge. . . . ."[1/]

1/ Speech before the American Bar Association in Montreal, Canada, August 11, 1975.

Even prior to the statements by the President and the Secretary of State, the Department of the Interior layed the ground work for these policies. As early as 1966, Secretary of the Interior Stewart Udall publicly proclaimed the Department's intention to participate heavily in continuing satellite surveys of the Earth. This decision was largely based on three considerations:

a. Concern that there was not sufficient data, and hence knowledge, to permit wise stewardship of our national lands;

b. Recognition that our dependence on foreign resources was growing, and

c. a belief that a set of objective, timely data was neeced to assess the environmental impact of man's development activities.

An important element of the Secretary's proclamation concerned the open availability of data, "the information gained . . . . . will be synthesized and made generally available. . . . . ."

The Secretary's comments were amplified by Under Secretary William T. Pecora. Pecora said "The course seems clear; we must make and execute bold plans to gather data on the Earth's resources, and at assessing, inventorying, and disseminating these data in order to alleviate resource problems common to all nations."

Prior to seeking appropriations for the establishment of a Departmental program, Dr. Pecora discussed the international aspects and implications of the program with the Administration and the Congress. With this background of communication, the Department of the Interior sought and received, from the Administration and the Congress, the authority and the means to establish the EROS Program and to accomplish the construction of a facility (the EROS Data Center) to serve the national and international scientific communities. This facility was to provide for the cataloging, processing and dissemination of satellite-derived data and training in their use.

In summary, consistent with national and Departmental policies, Interior personnel presently conduct research in foreign test sites, assist foreign governments in the use of remote sensing technology, provide training to foreign nationals, both in the U.S. and abroad, and supply remote sensing data to the world. These activities have placed the Interior Department in a pivotal role in the international community which now makes use of, or wishes to make use of remote sensing data. This role has been recognized by other bodies studying the question of the international use of remote sensing from space. In the 1977 report of the National Academy of Sciences "Resource Sensing from Space: Prospects for Developing Countries" it is stated "Concerned with the international supply of scarce raw materials, the U.S. Geological Survey has a long history of collaboration with its counterpart agencies abroad, especially in the developing countries . . . . clearly, the Geological Survey constitutes an important U.S. asset for dissemination of remote

sensing skills, one to which the United States will need to make increasing resort especially to help meet the developing countries' large requirement for trained personnel."

Future Departmental Roles in Systems with Global Capabilities

It is apparent from the foregoing discussion that the Department of the Interior has a global viewpoint in regard to resource surveys from space, and has earned a position of leadership in the application of this technology both domestically and internationally. This leadership should be continued and strengthened. For example, Interior should strongly represent its data needs and that of cooperating foreign nations, ensuring the data collected by global systems in the future meet the requirements of the Department. Some environmental issues which can be systematically addressed for the first time with the aid of Landsat data include:

1. Global distribution of glacial ice and areal change with time;
2. Global distribution of perennial snow and areal change with time;
3. Global distribution of sea ice and areal change, both seasonally and over longer periods of time;
4. Seasonal, annual, and longer term distribution of surface water;

5. Regional increase or decrease in desertification processes annually and over longer periods of time;

6. Rate of urbanization of range, forest, wetland, agricultural land; and

7. Rate of clear-cutting of forested areas and degree to which deforested areas are converted to other uses.

Participation in the deliberations of the OSTP Ad Hoc Committee of Earth Resources Surveys is an important first step, perhaps ultimately leading to legislation defining a continuing leadership role. In addition, Interior should seek a primary role in data dissemination, applications research, and training in the technology. This is a logical extension of the Departmental activities listed in Table I.

DEPARTMENTAL AND MANAGEMENT POSITION OF EROS

Table I: Selected Examples of Departmental International Activities Related to Satellite Remote Sensing

--Provided data to more than 120 nations through the EROS Data Center;

--Provided training in the U.S. in the use of remote sensing data to approximately 200 scientists from foreign nations;

--Conducted or helped carry out approximately two dozen regional training seminars or workshops in other countries;

--Cooperated closely with the Department of State in determining the usefulness of satellite data in disaster assessment;

--Demonstrated the utility of enhanced Landsat imagery for identifying and separating lithologic units in Saudi Arabia;

--Demonstrated the utility of computer-processing of Landsat data in identifying mineralized areas in Pakistan;

--Demonstrated the value of repetitive Landsat imagery for monitoring floods in Bangladesh, oceanic upwelling in the Indian Ocean, and hydrologic changes in Iran;

--Performed cooperative scientific experiments with Bolivia and Chile regarding structural geology and minerals potential of Salars;

--Conducted continuing, cooperative remote sensing studies with Iceland;

Table I: (Continued)

--Demonstrated applicability of Landsat data for geologic mapping in Andes Mountains in Venezuela and for defining gold and tin placers in Bolivia;

--Demonstrated applications of airborne and satellite remote sensing data in resource surveys in the Central African Empire;

--Established the technical exchange of data relative to Landsat with mapping organizations throughout the world. (Includes shallow-seas mapping as well as small scale image mapping and map revision);

--Participated continuously in coordination meetings with foreign Landsat reception/processing facilities;

--Supported the U.S. in bilateral studies of space-derived remote sensing data with U.S.S.R.;

--Advised the Inter American Development Bank in formulating program for resource inventory of Central America. Provided overview training for Bank specialists;

--Established an international information exchange project on Remote Sensing and Mineral Exploration under UNESCO's International Geologic Correlation Program. Over 70 scientists from 35 nations are participating in the Program;

--Introduced data collection platforms systems to Latin America.